

TITLE OF THE INVENTION

WRITE-ONCE DISC RECORDING SYSTEM WITH AUDIO  
AFTER-RECORDING CAPABILITY

CROSS-REFERENCE TO RELATED APPLICATIONS

5           This application is based upon and claims the  
benefit of priority from the prior Japanese Patent  
Application No. 2000-399293, filed December 27, 2000,  
the entire contents of which are incorporated herein by  
reference.

10                           BACKGROUND OF THE INVENTION

1. Field of the Invention

          The present invention relates to an optical disc  
recording/reproduction system for editing audio  
information after recording on a write-once, read-many  
15       optical disc on/from which video information and/or  
audio information can be recorded and reproduced.

2. Description of the Related Art

          In recent years, DVD (Digital Versatile Disc) has  
been developed and produced in various forms, and such  
products have prevailed. Further, the market requires  
20       higher-performance products across various fields. To  
meet such requirements, the DVD forum has specified a  
DVD-RAM disc that allows recording/reproduction, i.e.,  
"DVD Specifications for Rewritable Disc, Part 1:  
25       PHYSICAL SPECIFICATIONS, Part 2: FILE SYSTEM  
SPECIFICATIONS", or a DVD-RW (Re-recordable) disc,  
i.e., "DVD Specifications for Re-recordable Disc,

Part 1: PHYSICAL SPECIFICATIONS, Part 2: FILE SYSTEM SPECIFICATIONS" in 1999. Moreover, DVD video recording (DVD video recording) specifications as application specifications that exploit these rewritable discs, i.e., "DVD Specifications for Rewritable/Re-recordable Discs Part 3: VIDEO RECORDING" have been issued in September 1999, and products which use the specifications have been put on the market at the end of 1999.

In September 2000, a DVD-R for general disc "DVD Specifications for Recordable Disc for General, Part 1: PHYSICAL SPECIFICATIONS, Part 2: FILE SYSTEM SPECIFICATIONS" as a write-once, read-many disc, which can be applied to the DVD video recording application specifications, was added in addition to the aforementioned rewritable discs.

Originally, the requirement specifications and function specifications of the DVD video recording application specifications were determined and specified on the basis of the aforementioned rewritable disc. Upon application to a write-once, read-many disc, since its recording method is different from that of the rewritable disc, some new devices are required to implement all functions specified by the video recording application specifications.

As a disclosed technique that pertains to an audio after-recording function, Jpn. Pat. Appln. KOKAI

Publication No. 11-298,845 is known. This reference has exemplified an after-recording process for a rewritable DVD-RAM (Random Access Memory). However, this reference is not directed to a write-once, read-many disc, and discloses an audio-only after-recording process.

The audio after-recording function requires a sequence for reading out an audio stream of an audio after-recording area, executing after-recording edit of the readout audio stream, and then writing back the edited stream. Therefore, in a write-once, read-many disc such as a DVD-R or the like in which data once written in a given area cannot be rewritten, such audio after-recording function cannot be implemented.

#### BRIEF SUMMARY OF THE INVENTION

According to an aspect of the present invention, a new audio stream created as a result of an after-recording process is additionally recorded in a new storage area in place of being overwritten on the recorded stream, thus allowing to repeat the after-recording process even in a write-once disc such as a DVD-R.

#### BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

FIG. 1 is a block diagram showing an embodiment of an optical disc recording/reproduction system (apparatus) with an audio after-recording function according to the present invention;

FIG. 2 is an explanatory view for explaining an embodiment of the audio after-recording function of the optical disc recording/reproduction system with an audio after-recording function according to the present invention;

FIG. 3 is an explanatory view for explaining another embodiment of the audio after-recording function of the optical disc recording/reproduction system with an audio after-recording function according to the present invention;

FIG. 4 is a flow chart showing the recording operation of the optical disc recording/reproduction system with an audio after-recording function according to the present invention; and

FIG. 5 is a flow chart showing the reproduction operation of the optical disc recording/reproduction system with an audio after-recording function according to the present invention.

#### DETAILED DESCRIPTION OF THE INVENTION

An embodiment of an optical disc recording/reproduction system (apparatus) with an audio after-recording function will be described in detail hereinafter with reference to the accompanying drawings.

FIG. 1 is a block diagram showing an optical disc recording/reproduction system with an audio after-recording function according to an embodiment of the

present invention.

<Example of Arrangement of Optical Disc  
Recording/reproduction Apparatus>

Optical disc recording/reproduction apparatus R  
5 comprises disc drive 1 for write-once, read-many  
optical disc (e.g., DVD-R disc) D. The apparatus R  
also comprises key input unit 19 for respective  
operations, reproduction block B1 for a reproduction  
process of an optical disc, recording block B2 for a  
10 recording process, MPU 9 for controlling the optical  
disc recording/reproduction apparatus, memory 10 mainly  
used to execute data processes, and ROM 20 for storing  
at least programs of respective operation processes  
such as sequences that allow an audio after-recording  
15 function according to an embodiment of the present  
invention.

Reproduction block B1 has data processor 2 for  
performing signal demodulation and error correction of  
data output from disc drive 1, and demultiplexer (DMUX)  
20 3 for demultiplexing a data sequence in a pack format,  
which forms a time-division multiplexed MPEG2 program  
stream output from data processor 2, into four types of  
packs, i.e., video packs consisting of video data, sub-  
picture packs consisting of sub-picture data, audio  
25 packs consisting of audio data, and control packs  
consisting of control data, and transferring respective  
data to corresponding decoders, i.e., a video decoder

4, sub-picture decoder 5, and audio decoder 6, and control data to memory 10, which can be referred to by MPU 3, with reference to ID data which are recorded in respective data and indicate their transfer times and data types.

Video decoder 4 decodes video data transferred from demultiplexer 3, and transfers decoded data to video processor 7. Sub-picture decoder 5 decodes sub-picture data transferred from demultiplexer 3, and transfers decoded data to video processor 7. Audio decoder 6 decodes audio data transferred from demultiplexer 3, and transfers decoded data to D/A converter 8. Video processor 7 mixes data output from video decoder 4 and sub-picture decoder 5. D/A converter 8 converts a digital signal output from audio decoder 6 into an analog signal. The signal converted by D/A converter 8 is reproduced by a TV monitor, loudspeaker, and the like (not shown) via video and audio output terminals.

Memory 10 temporarily saves data, and key input unit 19 is provided to receive user's instructions and requests.

In the recording block shown in FIG. 1, A/D converters 11 convert data input via video, audio, and sub-picture input terminals from analog signals into digital signals. Video encoder 12 encodes digital video data converted by A/D converter 11. Sub-picture

encoder 13 encodes digital sub-picture data converted  
by A/D converter 11. Audio encoder 14 encodes digital  
audio data converted by A/D converter 11. Multiplexer  
(MUX) 15 packetizes and packs video, audio, and sub-  
5 picture data encoded by the respective encoders into  
video, audio, and sub-picture packs to form an MPEG2  
program stream.

File formatter 16 converts a multiplexed data  
group into a file complying with a file structure which  
10 can be recorded/reproduced by the optical disc  
recording/reproduction apparatus R. Volume formatter  
17 forms a data format complying with a volume  
structure which can be recorded/reproduced by the  
optical disc recording/reproduction apparatus R.  
15 Volume formatter 17 appends data which has been  
converted into a file by file formatter 16,  
reproduction control information used to reproduce that  
data which has been converted into a file, and the  
like. Physical formatter 18 is provided to record data  
20 on optical disc D. File formatter 16 and volume  
formatter 17 are logical formatters, and physical  
formatter 18 is a disc formatter for recording data  
which has been formatted by these formatters on optical  
disc D via disc drive 1.

25 ROM 20 stores a series of processing programs of  
the optical disc recording/reproduction apparatus R,  
and the apparatus operates when these programs are

executed by MPU 9.

According to a DVD specification for Rewritable/Re-recordable discs (or DVD video recording specifications), a primary audio stream and a secondary audio stream are available. The primary audio stream whose stream number is '0' has two states (original state and modified state) and the secondary audio stream whose stream number '1' has four states (original state, modified state, dummy state, and after-recorded state).

Further, a management information (RTR\_VMG/M\_AVFIT/M\_AVFI/M\_VOBI/M\_VOB\_GI) defined in the DVD specification for Rewritable/Re-recordable discs includes type information (VOB\_TY) of a data object (VOB). (The VOB may be formed of video object data relating to video streams and of audio object data relating to audio streams.) The type information includes two status information items (A0\_STATUS and A1\_STATUS).

When A0\_STATUS = 00b, audio stream#0 (stream A0) is recorded as an original audio stream when the VOB was created, and it has not been modified. The player (reproduction block B1 in FIG. 1) shall allow a user to select this audio stream to be presented.

When A0\_STATUS = 01b, audio stream#0 (stream A0) is recorded as an original audio stream when the VOB was created, and it has been modified partially or



entirely. The player (reproduction block B1) shall allow a user to select this audio stream to be presented.

Incidentally, the state of each of A0\_STATUS = 10b and A0\_STATUS = 11b is reserved.

When A1\_STATUS = 00b, audio stream#1 (stream A1) is recorded as an original audio stream when the VOB was created, and it has not been modified. The player (reproduction block B1) shall allow a user to select this audio stream to be presented.

When A1\_STATUS = 01b, audio stream#1 (stream A1) is recorded as an original audio stream when the VOB was created, and it has modified partially or entirely. The player (reproduction block B1) shall allow a user to select this audio stream to be presented.

When A1\_STATUS = 10b, audio stream#1 (stream A1) is recorded as a dummy audio stream for audio dubbing purpose when the VOB was created, and it has not been modified yet (or, audio dubbing has not been done yet). This audio stream shall be the same as the primary audio stream (A0) except for a stream number at the packet layer. The player (reproduction block B1) shall not allow a user to select this audio stream to be presented.

When A1\_STATUS = 11b, audio stream#1 (stream A1) is recorded as a dummy audio stream for audio dubbing purpose when the VOB was created, and has already been

modified partially or entirely (or, audio dubbing has already been done). The player (reproduction block B1) shall allow a user to select this audio stream to be presented.

5           Incidentally, when A1\_STATUS = '10b' or '11b', then A0\_STATUS = 01b shall not be described. When audio stream#0 and audio stream#1 have the same contents, audio stream#1 shall be modified in stead of audio stream#0.

10           In the following, description will be given to the state of audio stream and the mechanism to dub after-recorded audio stream without any modification of the original audio stream.

            The primary audio stream whose stream number is  
15    '0' has two states and the secondary audio stream whose stream number is '1' has four states as follows:

<Primary audio stream>

\* Original state (A0\_STATUS = 00b)

            This state indicates that the primary audio stream  
20    is an original audio stream which was recorded at the same time when the VOB, which indicates this primary audio stream, was created.

\* Modified state (A0\_STATUS = 01b)

            This state indicates that the primary audio stream  
25    has been modified partially or entirely after the VOB, which indicates this audio stream, was created.

<Secondary audio stream>

\* Original state (A1\_STATUS = 00b)

This state indicates that the secondary audio stream is an original audio stream which was recorded at the same time when the VOB, which indicates this audio stream, was created.

\* Modified state (A1\_STATUS = 01b)

This state indicates that the secondary audio stream has been modified partially or entirely after the VOB, which indicates this audio stream, was created.

\* Dummy state (A1\_STATUS = 10b)

This state indicates that the secondary audio stream is a dummy audio stream to be dubbed into after-recorded audio stream for the future.

In this state, the secondary audio stream shall be the same as the primary one except for a stream number at the packet layer.

In other words, the N-th pack in the sequence of the secondary audio stream (A1) shall include the same audio data that the N-th pack in the sequence of the primary audio stream (A0) includes.

The player (reproduction block B1 in FIG. 1) shall not present the secondary audio stream in the dummy state.

\* After-recorded state (A1\_STATUS = 11b)

This state indicates that the secondary audio

stream has been modified partially or entirely after the VOB, which indicates this audio stream, was created.

5       The difference from the modified state  
      (A1\_STATUS = 01b) is that the after-recorded state  
      (A1\_STATUS = 11b) is able to be transited from only the  
      dummy state (A1\_STATUS = 10b).

10       More specifically, when any modification is  
      executed, the state of the secondary audio stream shall  
      be transited from the dummy state to the after-recorded  
      state. When the secondary audio stream is restored to  
      the original audio stream completely using the primary  
      one, the state of the secondary audio stream shall be  
15       transited from the after-recorded state to the dummy  
      state.

      In the following, description will be given to a  
      manner of multiplexing a dummy audio stream.

20       The secondary audio stream which is a dummy audio  
      stream to be replaced by an after-recorded audio stream  
      needs to be recorded for reserving a room at VOB  
      recording time, because no room for the after-recorded  
      audio stream is reserved in a general MPEG Program  
      stream.

25       The secondary audio stream shall be the same as  
      the primary one except for a stream number at the  
      packet layer. When the audio streams are recorded, the  
      A1\_STATUS may be set to '10b' that means this audio

stream is recorded to be dubbed into an after-recorded audio stream in the future. If the A1\_STATUS may be set to '10b', the player (reproduction block B1 in FIG. 1) shall not present the secondary audio stream, because the audio content of this stream is the same as that of the primary one.

In the following, description will be given to a manner of replacing the secondary audio stream by an after-recorded audio stream.

10 If the recorder (recording block B2 in FIG. 1), which has a capability to dub an after-recorded audio stream, finds the A1\_STATUS set to '10b', the recorder may replace the recorded audio stream by the after-recorded audio stream at pack-by-pack manner.

15 In the following, description will be given to a manner of restoring the after-recorded audio stream to the original audio stream.

If a user wants to restore the after-recorded audio stream to the original audio stream, it is able to be restore using the primary audio stream. Because the dummy audio stream is the same as the primary one except for a stream number at the packet layer, restoring the secondary audio stream may be performed by replacing the modified packets with the original one kept in the primary audio stream. After this operation, the A1\_STATUS shall be set to '10b'.

<Processing Operation of Optical Disc  
Recording/reproduction Apparatus>

The operation principle of the aforementioned  
optical disc recording/reproduction apparatus R will be  
5 described in detail below using the accompanying  
drawings.

FIG. 2 is an explanatory view showing an  
embodiment of the present invention which implements an  
audio after-recording function specified by the DVD  
10 video recording application specifications using a  
DVD-R (write-once, read-many disc) for general.

As shown in (a) of FIG. 2, area A of DVD-R disc D  
records in advance two audio streams, i.e., first audio  
stream (primary audio stream) A0, and second audio  
15 stream (secondary audio stream) A1 which has the same  
contents as the first audio stream and is recorded for  
the purpose of after-recording.

Upon executing audio after-recording in DVD-R disc  
D, the reproduction block B1 of the optical disc  
20 recording/reproduction apparatus R shown in FIG. 1  
reads out the contents of area A from DVD-R disc D, and  
stores them in memory 10.

As shown in (b) of FIG. 2, the acquired data is  
formed of a data pack sequence including video packs  
25 (V), first audio packs (A0), second audio packs (A1),  
and the like. In memory 10, the audio packs are  
converted into an audio stream, as shown in (c) of

FIG. 2, and second audio stream A1 is partially or entirely replaced by another audio stream A1' in accordance with an audio after-recording execution range designated by the user via key input unit 16, as shown in (d) of FIG. 2. After that, the audio stream is converted into audio packs, and these audio packs are then converted into an original data pack sequence, as shown in (e) of FIG. 2.

The recording block B2 of the optical disc recording/reproduction apparatus shown in FIG. 1 additionally records the obtained sequence in area B of DVD-R disc D, as shown in (a) of FIG. 2, thus implementing the audio after-recording function.

After completing the above audio after-recording, contents of original area A may be invalidated (or inactive) and contents of newly recorded area B may be validated (or active).

Note that a series of processing sequences mentioned above is attained by executing an audio after-recording processing program stored in ROM 20 by MPU 9.

FIG. 3 is an explanatory view for explaining an example that implements the audio after-recording function. This audio after-recording function is attained by changing file management information that manages the entire reproduction data file, since the audio after-recorded area described using FIG. 2 is handled as a file extent. The portion (a) of FIG. 3

shows a data recording area of DVD-R disc D before audio after-recording, and the portion (b) shows a data recording area of DVD-R disc D after audio after-recording.

5           Reproduction data file F0 before audio after-recording in (a) of FIG. 3 is formed of four file extents E1 to E4 in areas a, b, c, and d. Upon executing the audio after-recording function explained in FIG. 2 for area c of file extent E3 which forms  
10           reproduction data file F0, the data obtained after the audio after-recording is additionally recorded in area X. At the same time, area c (file extent E3) is excluded from reproduction data file F0, and area X is defined as file extent E3N of reproduction data file  
15           F0, as shown in (b) of FIG. 3, thus implementing the audio after-recording function specified by the DVD video recording specifications.

          Therefore, at this time, reproduction data file F0 after audio after-recording is formed of four file  
20           extents E1 to E4 in areas a, b, X, and d.

          FIG. 4 is a flow chart showing the recording operation of an optical disc recording/reproduction apparatus (R in FIG. 1) with an audio after-recording function according to an embodiment of the present  
25           invention. The recording operation will be explained below using this flow chart.

          Referring to FIG. 4, when the audio



after-recording function starts, a user designates the audio after-recording range. Then, optical disc recording/reproduction apparatus R in FIG. 1 reads file extent E3 from disc D via disc drive 1 using data processor 2 in reproduction block B1, and executes ECC processing of the read file extent E3. The read file extent E3 (having been subjected to the ECC processing) contains an area (c) corresponding to the user designated range in reproduction data file F0. The apparatus R acquires a data pack sequence of the read file extent E3 using demultiplexer 3, and stores that sequence (data packs) in memory 10 (step S11).

From the acquired data pack sequence, the packs of the second audio stream are converted into an audio stream which can be edited for respective audio frames (one audio frame is 1/600 sec in linear PCM at sub-sampling frequency 48 kHz, and quantization bit 16 bits) (step S12).

The second audio stream, i.e., the content of file extent E3 in area c is partially or entirely replaced by an audio stream for after-recording, in units of audio frames, according to the user designated range. This audio stream for after-recording can be obtained by converting an analog audio signal, input from an audio input terminal, into a digital audio signal by A/D converter 11 (step S13).

Furthermore, the second audio stream that has

undergone audio after-recording is converted into audio packs, which are re-arranged in the data pack sequence (step S14).

5 Finally, the data pack sequence is converted via multiplexer 15 to form a data structure complying with the DVD video recording specifications by means of file formatter 16, volume formatter 17, and disc formatter 18 in recording block B2.

10 Then, data that has undergone audio after-recording is additionally recorded in unrecorded data X of DVD-R disc D as new file extent E3 of reproduction data file F0 (step S15).

15 With this process, data according to the after-recording process is written in new storage area X and, hence, the writing according to the audio after-recording process can be made on a write-once, read-many disc such as DVD-R wherein data can be written only once for each storage area.

20 FIG. 5 is a flow chart showing the reproduction operation in the optical disc recording/reproduction apparatus with an audio after-recording function according to an embodiment of the present invention.

25 Referring to FIG. 5, when reproduction including an area that has undergone audio after-recording starts, the file extents of reproduction data file F0 are extracted in turn from a file entry recorded in file management information (step S21).

The reproduction block B1 reads out and reproduces areas a and b, additionally recorded area X, and area d in turn from DVD-R disc D via disc drive 1 in accordance with the extracted file extents (step S22).

5           In this case, another audio stream (A1' in (d) of FIG. 2) in additionally recorded area X that has undergone audio after-recording is automatically selected in place of an audio stream (A0 in (d) of FIG. 2) that stores original data. The automatically  
10       selected audio stream (A1') is reproduced and output to an audio output terminal (step S23).

Such operation processing is done when MPU 9 processes according to the program stored in ROM 20. In this way, latest audio data that has undergone the  
15       audio after-recording process can be reproduced in synchronism with the related video signal stored together, without any user's notice about the audio after-recording process.

In the optical disc recording/reproduction  
20       apparatus according to an embodiment of the present invention, since an audio stream can always be recorded/reproduced together with the related video signal, no buffer occupation by computations for a seek process in mutual access is generated as a result of  
25       independent processes of an audio after-recording signal and video signal, and a highly reliable optical disc recording/reproduction system (apparatus) being

free of any operation errors can be provided.

As described above, an aspect of the present invention can provide an optical disc recording/reproduction system (apparatus) which can implement an audio after-recording function specified by the DVD video recording application specifications, since it additionally records an audio stream in a new area of even a write-once, read-many optical disc such as DVD-R or the like, which conventionally does not allow an audio after-recording process.

According to the above system (apparatus), the audio after-recording can be repeated using a write-once disc such as DVD-R, CD-R, or the like, such that new audio streams each created by the audio after-recording are additionally recorded on the unrecorded area of the write-once disc, and the corresponding data file (management information) is updated.

Further, the new audio streams additionally recorded on the unrecorded area of the write-once disc can be automatically selected at the time of reproduction.

The audio after-recording using a write-once disc such as DVD-R can be reduced to practice without changing the existing DVD standard.